1.2.1 Electronic computers based on digital switching

The first true digital electronic computer was created by John V Atanasoff during 1937-1942. The Atanasoff-Berry Computer (called ABC figure 2.8) was the first to use modern digital switching techniques. Vacuum tubes were used as switches (the needs of switches are explained later). The concepts of using binary arithmetic and logic circuits were introduced to computing world by this ABC.
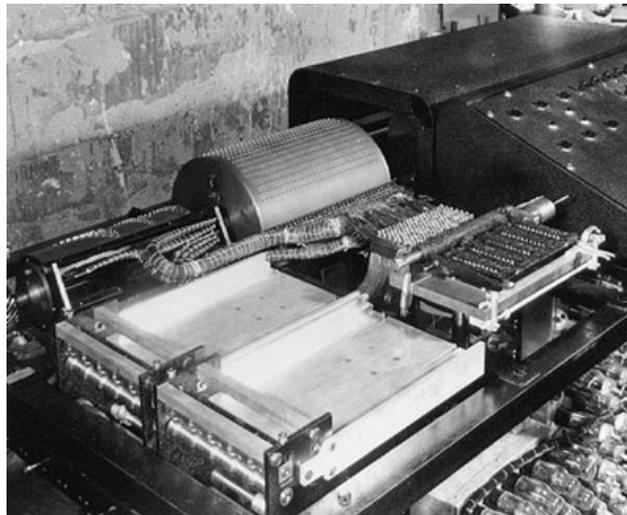

Figure 1.21: Atanasoff-Berry Computer

The first large-scale electronic computer for the military which was named as ENIAC (Electrical Numerical Integrator and Calculator figure 2.9) was invented in 1946 by John Presper Eckert and John William Mauchly. This was a valve based computer and now referred to as a first generation computer. ENIAC had the following characteristics:

- Operated on 10-digit numbers and could multiply two such numbers at the rate of 300 products per second.
- Was about 1000 times faster than the previous generation of electromechanical relay computers.
- Was a valve based computer.
- Used approximately 18,000 vacuum tubes, and occupied 1,800 square feet of floor space and consumed around 180,000 watts of electrical power.
- Punch cards were used as input and output and registers served as adders and also as quick-access read/write storage.
- The executable instructions of a program were created using specified wiring and switches that controlled the flow of computations through the machine. AS such, ENIAC had to be rewired and switched for each program to be run.
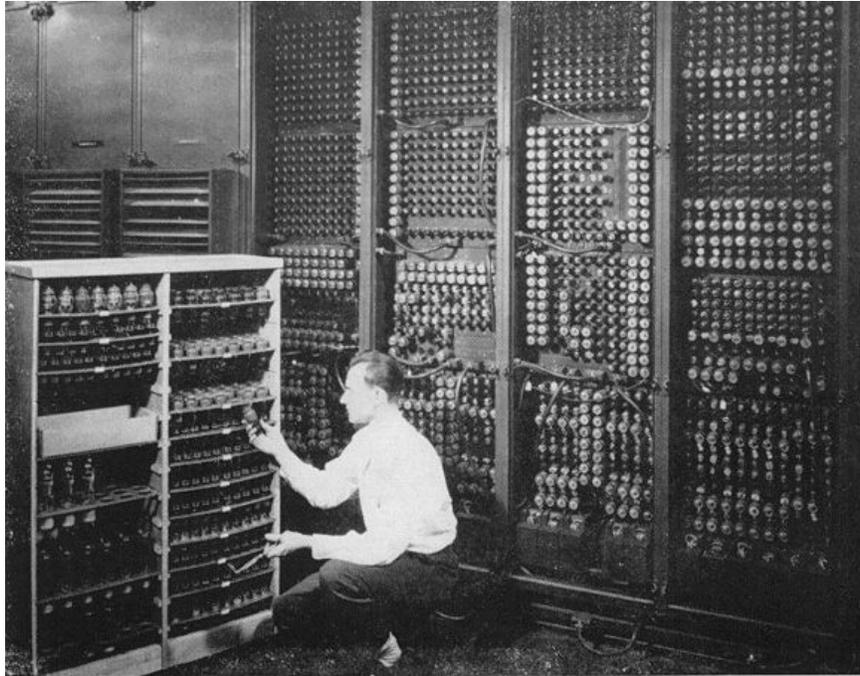
Replacing a bad tube meant checking among ENIAC's 19,000 possibilities.

Figure 1.22: ENIAC

John Von Neumann introduced the idea of using the computer as a fixed physical structure and to use programmed control, without the need for any change in hardware. This allowed executing many different programs (tasks) without changing the physical structure of the computer. The Von Neumann's idea is known as the "stored-program technique" (figure 2.10. This idea became the base for the future generation high-speed computers and is used by modern day computers.
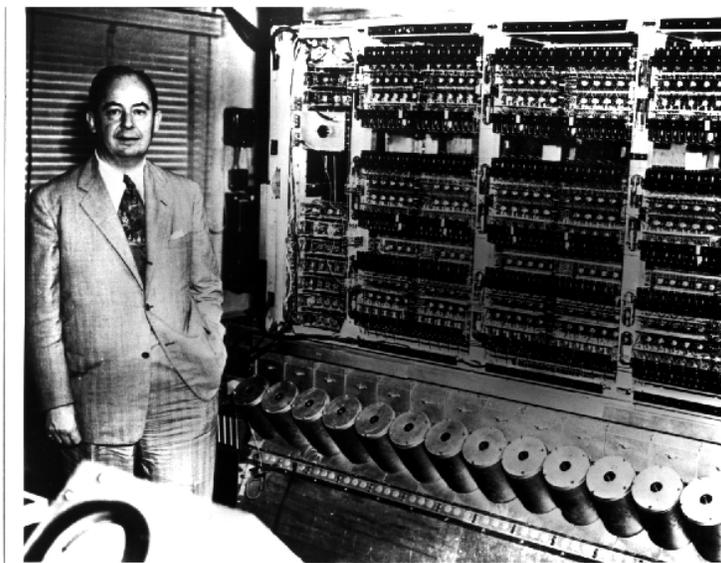

Figure 1.23:

1.2.2 UNIVAC to the modern day computers

At around 1947 computers started to use these ideas mentioned above such as stored-program technique. They are now considered as first generation computers. Some machines introduced at this time are EDVAC and UNIVAC (Universal Automatic Computer figure 2.11). These computers used the concept of RAM (Random Access Memory) for the first time. The RAM was used to store programs and data when the computer is functioning. They used the machine language to write programs and later computers started to use high-level languages. UNIVAC was the first true general-purpose computer which was able to manipulate both alphabetical and numerical programs. This made computers available not only for science and military, but also for business.
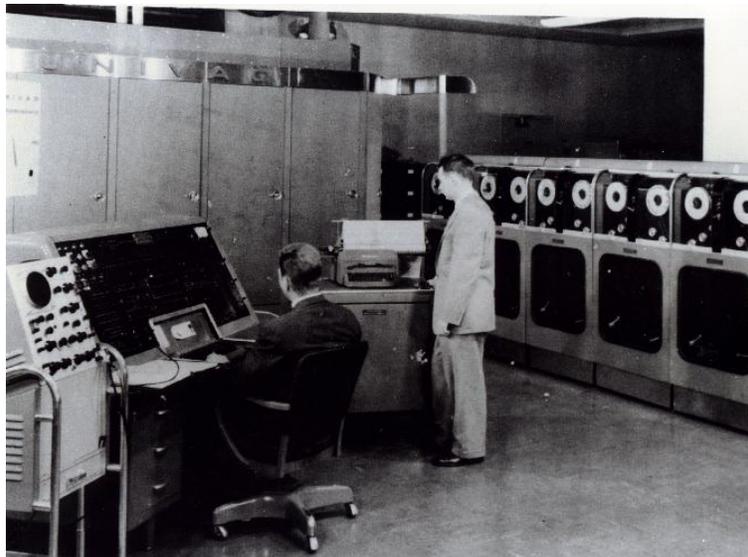
Figure 1.24: UNIVAC

From UNIVAC to today, computers have developed and changed a lot. The first generation computers used vacuum tubes in their construction and today we use integrated circuits which are much smaller and more efficient.

The computers are using a mode of on/off when it is functioning. This is called as the binary system since it represent 1 and 0, or true and false. To implement this, an efficient switch is required. A digital computer needs a large number of such switches. The first electronic computers used vacuum tubes (figure 2.12) as switches, and although the tubes worked they had many problems.

Figure 1.25: Vacuum Tube

Early computers used a type of tube called "triode" (three pin vacuum tube). This tube was not that much good to be used as a switch. It needed a lot of electrical power and generated a massive amount of heat and in-turn lead to the tube to fail frequently. The invention of the transistor (figure 2.13) made a revolution of computers. The size of the transistor was very small and in-turn made the size of the computer much smaller. The transistor was much faster than the earlier computers built using vacuum tubes and was much more reliable. Compared to the tube, transistor was much more efficient as a switch.
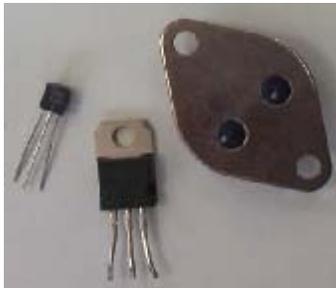
Figure 1.26: Transistor

The invention of the transistor and then the conversion from tubes to transistors has lead to greatly reducing the size of computers used today. The introduced of integrated circuits (figure 2.14) which contains millions of transistors in a small pack, have made the computers more and more smaller in size. Some computers today are very small in size which would even fit on to a palm of a person and consumes very little amount of power (provided using batteries). This is a great improvement compared to computers which we had at the earlier days which filled large room spaces and consumed huge amounts of electrical power. Today most of the consumer applications have replaced vacuum tubes with transistors and integrated circuits . But still vacuum tubes are used for high-end audio applications because they produce a warmer and richer sound than transistors do.

Figure 1.27: Integrated circuit

Modern computers use integrated circuits (ICs), but not individual transistors. An integrated circuit consists of multi-millions of transistors. (Note that the first integrated circuit contained only six transistors in it). In June 2001, Intel researchers invented the world's smallest transistor. This will allow billions of transistors to be packed in a very small unit and in-turn reduce the size of the computer largely. In year 2003 AMD Athlon 64 processor (figure 2.15) was introduced with more than 105.9 million transistors and Pentium 4 Extreme Edition (figure 2.16) processor was introduced with more than 178 million transistors.

Figure 1.28: AMD Athlon 64-Bit Processor

Figure 1.29: Intel Pentium 4 processor

Microprocessor history

The processor (also known as the microprocessor or Central Processing Unit (CPU)) is the heart of a computer system. The processor is the unit which performs all the calculations (the processing) in a computer system. The processor also controls the other units in the computer system.

The following lists some of the important details about the history of microprocessors and how they have evolved.

- In 1970, Intel introduced a 1Kb memory chip. This was very much large than what was available at that time. It was known as 1103 (figure 2.17) Dynamic Random Access Memory (DRAM). By next year this became the world's most selling semiconductor device. Intel was recognised as a successful memory chip company in the 1970s. In 1971 Intel introduced the 4-bit Intel 4004 (figure 2.18) microcomputer set (however the term microprocessor was not used until later). This was very small in size and contained 2,300 transistors. This delivered as much as computing power as ENIAC. When you compare the two ENIAC used 18,000 vacuum tubes and used 3000 cubic feet in size when it was built in 1946. The Intel 4004 microprocessor executed at 108 KHz and was able to execute 60,000 operations per second.
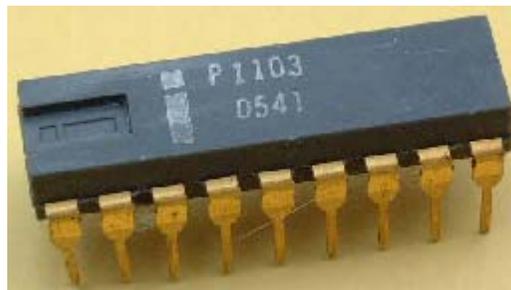

Figure 1.30: First Dynamic Random Access Memory Intel 1103
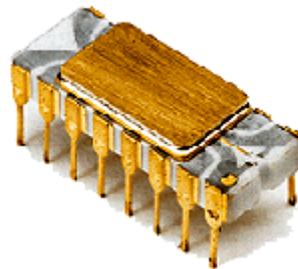

Figure 1.31: Intel 4004 Microprocessor

Note: Hz is a unit used to measure the speed of a microprocessor. (It is the number of clock cycles per second)

- Intel introduced the 8008 microcomputer in 1972, which processed 8 bits of information at a time, twice as much as the original chip. By 1981, Intel's microprocessor family had grown to include the 16-bit 8086 and the 8-bit 8088 processors. These two products lead to the production of the first PC, a product from IBM.

- In 1982 Intel introduced the 286 chip. The 286 offered software compatibility with its predecessors. This chip was first used in IBM's PC-AT, the system upon which all modern PCs are based.

- In 1985 the Intel 386 processor was released with a new 32-bit architecture. The chip could perform more than five million instructions per second (MIPS). Compaq's DESKPRO 386 was the first PC based on this microprocessor.

- In 1989 the Intel 486 processors was released. This had the first built-in math co-processor. This equalled the performance of some of the mainframe computers. (mainframe computers are explained later in this chapter)

- In 1993 Intel introduced the first P5 family (586) processor called the Pentium. The Pentium processor executes up to 90 MIPS (Million Instructions per Second). Note: Intel changed from using numbers (386/486) to names (Pentium/Pentium Pro) for its processors and this was based on the fact that it could not secure a registered trademark on a number and therefore could not prevent its competitors from using those same numbers on similar chip designs)

- In 1995 the first processor in the P6 (686) family, called the Pentium Pro processor was introduced. It was the first to be packaged with a second die containing high-speed L2 memory cache to accelerate performance. (Cache memory is explained in a later chapter)

- In 1997 Intel revised the original P6 (686/Pentium Pro) and introduced the Pentium II processor (figure 2.20). Pentium II processors had its transistors packed into a cartridge rather than a conventional chip, allowing them to attach the L2 cache chips directly on the module. The Pentium II family was augmented in April 1998, with both the low-cost Celeron processor (figure 2.22) for basic PCs and the high-end Pentium II Xeon processor (figure 2.19) for servers and workstations. Intel followed with the Pentium III in 1999, essentially a Pentium II with Streaming SIMD Extensions (SSE) added.
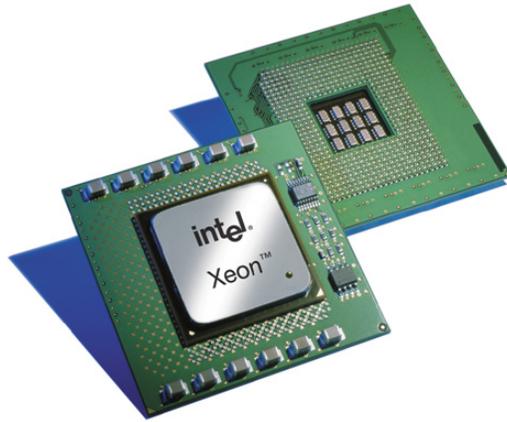
Figure 1.32: Intel Xeon microprocessor

Note: SSE represents a set of instructions integrated into Intel's Pentium III (figure 2.21) CPUs. They are intended to speed up CPU performance. SSE appears to offer significant improvements.
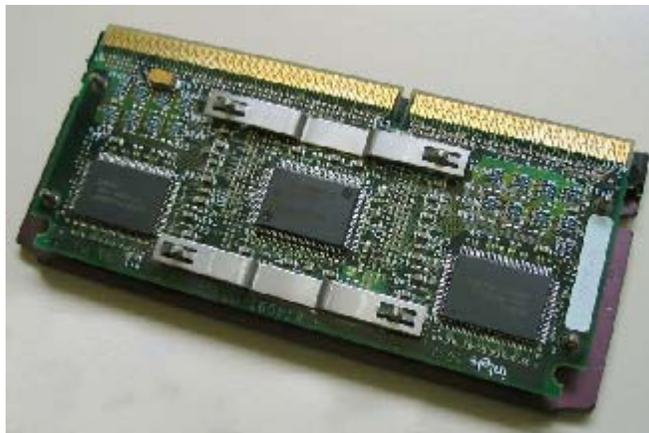
Figure 1.33: Intel Pentium II microprocessor

Figure 1.34: Intel Pentium III microprocessor

Figure 1.35: Intel Celeron microprocessor

- At the same time, AMD (Advance Micro Devices - another company) introduced its processor called AMD K6 (figure 2.23). The K6 was both hardware and software compatible with the Pentium, meaning it could be plugged to the same socket and could run the same programs. AMD continued making faster versions of the K6 and made a huge way in the low-end PC market by providing low-cost processors.
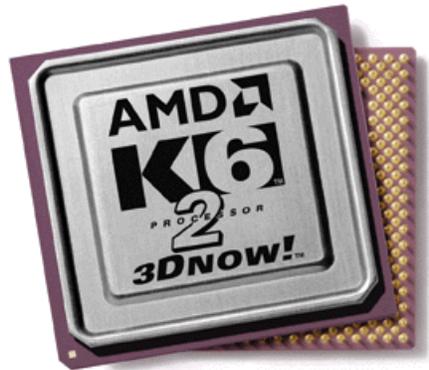
Figure 1.36: AMD K6 microprocessor

- In 1999 AMD introduced the Athlon to compete with Intel in high-end desktop PC market. Athlon required a motherboard with an Athlon supporting chipset and processor socket.
- In 2000 AMD introduced both its Athlon Thunderbird and Duron processors.
- In 2000 Intel introduced the Pentium 4 which is a 32-bit processor.
- In 2003 AMD released its first 64-bit processor which is Athlon 64.

Generations of Computers

The development of computers and the consideration of key developments have enabled computers to be categorised into various generations. Following is a summary of the generations of computers.

First Generation (1951-1958)
- Used vacuum tubes (figure 2.12) for internal operations
- Used low-Level languages for programming (machine language)
- Used magnetic drums for primary memory.
- Primary memory was limited.
- Heat and maintenance problems were there.
- Used punch cards for input and outputs.
- Input and output was slow.
- e.g. UNIVAC I, EDVAC

Second Generation (1958-1964)
- Used transistors (figure 2.13) for internal operations.
- Increased use of high level languages.
- Used magnetic cores for primary memory.
- Increased memory capacity.
- Binary coded data were used. (concept of binary is explained later)
- Increasing processing speed.
- Used magnetic tapes and disks for secondary storage

E.g. IBM 1620 (figure 2.24), UNIVAC 1108.

Figure 1.37: IMB 1620

Third Generation (1965-1970)

- Used (ICs) (figure 2.14) on silicon chips for internal operations.
- Memory capacity was increased.
- Minicomputers became a common use.
- Software industry emerged.
- Reduction in size and cost of computers happened.
- Increase in speed and reliability.

E.g. HONEY WELL-6000 SERIES (figure 2.25)

Figure 1.38: HONEYWELL 600 Series

Fourth Generation (1971-today)

- Used Large Scale Integration (LSI) and Very Large Scale Integration (VLSI) for internal operations.
- Development of the microprocessor happened.
- Introductions of micro and super computers.
- Increase in speed, power and storage capacity.
- Parallel processing was introduced.
- Artificial intelligence and expert systems were introduced.
- Robotics was introduced.
- Increased use of Micro/Personal Computers.

E.g. Apple II (figure 2.26), IBM PC (figure 2.27), Micro Computers

Figure 1.39: Apple II

Figure 1.40: IBM PC

Fifth Generation (1981-1990s)

- A project to develop intelligent computers.
- They are computers with artificial intelligence.
- Symbolic manipulation and symbolic reasoning is required.

Personal Computers

The Personal Computers (PC) is one of the most commonly used computer types in the world. In 1975 IBM introduced its first personal computer (PC). The PC named Model 5100 (figure 2.28) had 16Kb of memory, a built-in 16 x 64 character display, and a built-in BASIC language interpreter.

Figure 1.41: IBM 5100

Figure 1.42: Apple I

Started from here, today there are many different PCs available in the market. The PCs have evolved a lot by today compared to its inception in 1975. Today IBM PCs are based on microprocessors such as Intel Pentium 4 etc. The original PC had one or two single sided floppy drives that stored 160Kb and today we have PCs which have even 200Gb of disk space.

IBM originated the development of PCs and today there are many other companies who dominate in the PC industry such as Microsoft, Intel, and AMD etc.

1.3 Modern day computers

Modern day computers are much advanced than earlier computers. They help us in our day to day life, to get most of our tasks done. Today there are many different categories of computer systems available, such as:

- Supercomputers

- Mainframe computers
- Minicomputers
- Network servers
- Personal computers

Now we will look at each of these categories.

1.3.1 Supercomputers

Supercomputers (figure 2.30) are the most powerful computer systems available. Supercomputers are sophisticated, expensive computers, using state-of-the-art technology (modern technology at its best). Supercomputers are designed to perform large amounts of workloads and are used by researcher organisations, universities and by organisations which perform tasks which require enormous amount of computing power. Supercomputers are used in the simulation and modelling of complex systems. E.g. weather, chemical processes, US economic predictions, motion of galaxies. A supercomputer may have thousands of microprocessors in it and provides processing speeds, many times that of your home computer.
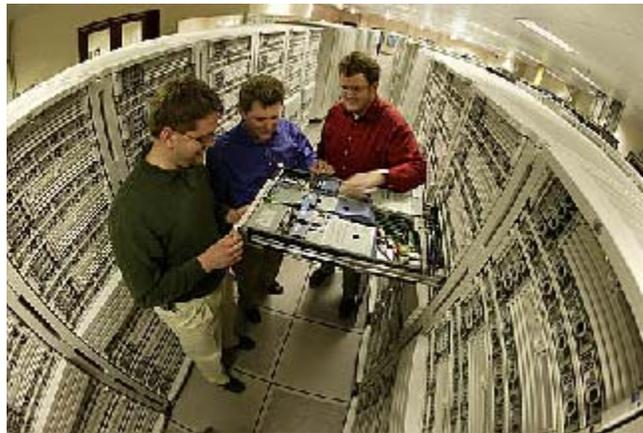

Figure 1.44: Super Computer

1.3.2 Mainframe computers

Mainframe (figure 2.31) computers are large powerful systems. Users connect to a mainframe computer and access the resources of the mainframe computer through a device called a terminal (figure 2.32). Terminals are of two types which are dumb terminals and intelligent terminals. Dumb terminals do not do any processing, it is used to connect and get tasks done by using the resources (processor, memory, storage) of the mainframe computer. In contrast an intelligent terminal has some limited processing power, but mostly don't have the capability of storing data. You can also use a standard personal computer to connect to the mainframe as it is done in some working environments.

A large mainframe computer can handle even more than 1000 users at a given time. For example an airline company can use a mainframe computer to handle its flight reservation systems, where some times large no of users might connect to the system at a given time.

However mainframe systems are less flexible to use. In use they are mostly dedicated to handler a single task or maybe a few tasks. That means mostly the mainframe is configured to handle a particular task so that the full utilisation of the mainframe computer can be used for processing that task. For example:

- A bank to handle the banking system
- An airline to handler the flight reservation system
- A country's motor department to store the details about registered vehicles

Figure 1.45: Mainframe Computer

Figure 1.46: Terminal connected to the Mainframe

1.3.3 Minicomputers

Minicomputers (figure 2.33) are computer systems which are less powerful than mainframe computers but more powerful than personal computers. They got the name because they were much small in size compared to the other computers at that time. Like mainframe computers, minicomputers also can handle many users at a time (can serve the needs of hundreds of users at the same time). You can connect to a minicomputer either by using a terminal or a personal computer.

Figure 1.47: Minicomputer

1.3.4 Network Servers

Organisations today use personal computers connected through a computer network (A computer network is a set of computers connected together so that they can share data and resources, access (communicate/talk) to the other computers in the network etc). When personal computers are connected through a computer network there should be a computer (which may also be a personal computer) to manage and supervise the computer network. Such a computer is known as Network Server (figure 2.34).

Because personal computers are general purpose computers, when an organisation has a computer network with personal computers it is very flexible. The uses of servers include:

• For the purpose of using email (i.e. as a email server)
• To connect to the Internet (i.e. as the proxy server)
• To share files (i.e. as the file server)
• To connect to a printer (i.e. as the printer server)
• To connect to a database (i.e. as the database server)

Note: A database is a software used to store and manage data in a much more organised way, as opposed to using normal files to store data.

Depending on how the network server is setup many users can connect to the network server to get various tasks done. Mostly in an office the employees will have a personal computer or a laptop on their desk and they will use this personal computer to connect to the network.
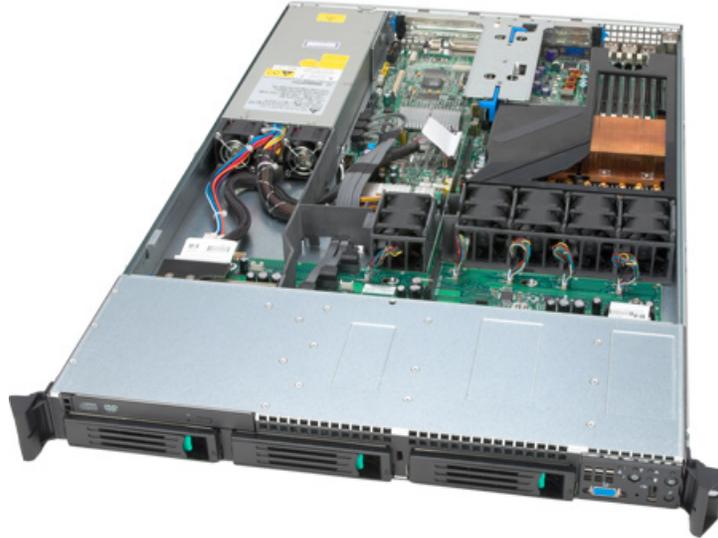
Figure 1.48: Network Server

1.3.5 Personal computers and Microcomputers

Computers which are designed to be used by a single person are known as Personal Computers (PCs). Personal computers have been very popular due it's small size and its ability to act as a general purpose machine. Most of the companies today assign personal computers to their employees to get done office work such as typing letters, drawing charts, performing day to day business transactions. Also today you find personal computers used at home by individual users. Personal computers are shared some times among students at places like universities, institutions. But only one person can use the computer at a time, which is one of the main characteristic of a personal computer. Personal computers are some times referred as microcomputers because their smaller size.

The following are some types of personal computers.
- Desktop computers
- Workstations
- Notebook computers
- Tablet PCs
- Hand-held personal computers
- Smart phones

1.3.5.1 Desktop computers

Desktop computers are a type of a personal computer and as the name implies it is meant to be placed on a desk or a table. Desktop computers are not meant to be carried around. Desktop computers are very popular among organisations. Organisations provide desktop computers to their employees to improve the work efficiency of the employees. Normally a desktop computer is meant to be used by a single user, but is mostly shared in real use, for example in a university or in a school, desktop computer are shared by students, but only one user at a time.

There are two kinds of desktop computers. One is a horizontal aligned flatbed (figure 2.35) type system and the other a vertical oriented tower (figure 2.36) type system. Desktop computers comprise a system unit which contains important parts of a computer system such as the microprocessor, hard disk, memory, floppy disk driver etc.

Figure 1.49: Flatbed model Desktop Computer

Figure 1.50: Tower model Desktop computer

1.3.5.2 Workstations

Workstations (figure 2.37) are a personal computer type which is powerful than desktop computers. It is a specialised computer mostly used by a single user. Workstations are most popular among scientists, video production crowd, animators, engineering designers etc due to its powerful capabilities and ability to perform complex tasks much faster.

Figure 1.51: Workstation computer

1.5.3.3 Notebook computers and Tablet PCs

As the name implies notebook computers (figure 2.38) takes the shape of a thin book. Notebook computers are very portable and some times are known as mobile computers because they can be carried with you (as opposed to desktop computers). These computers have less weight. To use it you can open up the cover (the upper part) of the notebook computer and then you get a thin display screen. The computer can be folded when not in use to make it more portable. Notebook computers are very popular among professional since they can carry it for meetings and workshops. These computers when in use could be kept on the lap and hence are also known as laptop computers. These notebook computers operate on the AC power and also can be used with a battery which comes with the computer.

Figure 1.52: Notebook computer

Tablet PCs (figure 2.39) are full equipped mobile computers which have all the features of a notebook computer plus more. It is more light weight than notebook computers and is very popular among people who travel and need to take notes while the computer is in hand (like architects). Tablet PCs have a special pen which they can use for this purpose. This special pen is known as the stylus or digital pen and the screen is touch-sensitive. You can use this pen to take notes on your computer and also to select and click certain icons. Some Tablet PCs have a microphone build in to take voice input and also can be connected to a network. Tablet PCs run special versions of certain software programs.

Figure 1.53: Tablet PC

1.5.3.4 Hand-held personal computers

As the name implies it fits in to your hand. They look like a very small note book and are in the same size as of a small note book. Hand-held personal computers are used mainly for purposes such as:

- taking notes
- to have your phone book contacts and address book contacts
- to have your appointment organiser
- to access a day calendar

Hand-held personal computers also have a special pen. You can write on the screen using this pen. For example when you want to take notes you can use this special pen. Some times you also get a tiny keyboard as well. Hand-held personal computers can also connect to a network and the Internet. Latest Hand-held personal computers have facilities of mobile phones and music players.

One popular type of a Hand-help personal computer is the Personal Digital Assistant (PDA). PDAs (figure 2.40) have all the features described above for a Hand-held personal computer.

Figure 1.54: PDA

1.5.3.5 Smart phones

Smart phones are special featured mobile phones. Smart phones are much bigger when compared to a normal phone. Some smart phones even have a tiny keyboard. Smart phones have some special features such as Internet and email facility, calendar facility, personal organiser facility etc. Also some smart phones have built-in digital cameras and music players.